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Impact of Age at First Calving on Lactation and Reproduction of First-Parity Iranian Holsteins Dairy Cows

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Abstract: The objective of this study, was to evaluate the effect of Age at First Calving (AFC) on cumulative first 60 and 200 days milk production and also reproductive performance in first-parity Iranian Holstein dairy cows. Data regarding to all calving of cows were collected during 1996 until 2006 in seven large commercial Holstein farms. Each cow has been characterized by demographic data, production and reproduction data. The dependent variables analyzed were the cumulative first 60 and 200 days milk production, days open and calving class. Data were analyzed using General Linear Models. The distribution analyze for the variables was done using the statistical software package JMP. The effect of the different levels of AFC on calving class was evaluated by nominal logistic analysis. The result showed that AFC averaged 27.23±3.37 month. Age at first calving decreased from 1996-2006 ($p<0.01$). Age at first calving had a significant impact on cumulative first 60 and 200 days milk production ($p<0.001$) but days open was similar among different levels of AFC. The AFC has impacted the calving class ($p<0.01$) and by increasing the AFC probability of eutocia increased and the probability of calving difficulty decreased ($p<0.01$). Cumulative first 60 and 200 days milk productions were also affected by calf weight at calving, calving class, herd and calving year and season ($p<0.001$). Days open was impact by the calving class, herd and calving year and season and increased over the years ($p<0.001$). The result of this study demonstrated that the milk yields increased by increase in AFC but the AFC had no impact on the interval from calving to conception. Age at first calving had significant impact on calving class and the probability of calving difficulties decreased by increase in AFC. The result also demonstrated that mean AFC is higher than the optimum age at first calving and can be decreased by 4 months.

Key words: Dairy cows, age at calving, lactation and reproduction, Iranian holsteins, Iran

INTRODUCTION

The productive life of a dairy cow is an indication of her utility and is influenced by her age at first calving, calving intervals, length of each lactation and success in surviving to another lactation (Hare *et al*., 2006). Age at First Calving (AFC) includes the period that a cow needs to reach maturity and to reproduce for the first time; calving intervals reflect the periods that a cow reproduces again. Age at first calving is one of the important factors contributing to economic return and is determined partially by farmer policy. Although, extension services encourage lower AFC as one of the most effective strategies for reducing replacement expenses, most farmers remain skeptical of calving at earlier than 24 mo. A decrease of age at parturition has a positive direct effect on genetic progress, as the generation interval decreases and the progeny test of sampling bulls is carried out earlier (Pirlo *et al*., 2000). Age at first calving also is an important factor in the cost of rearing replacements in dairy herds. There was an estimate decrease in rearing costs of 18% when calving age was reduced from 25 to 21 mo (Tozer and Heinrichs, 2001). Age at first calving can be manipulated by altering growth rates (Van Amburgh *et al*., 1998). However, even when heifers are managed and fed similarly to achieve similar growth rates, variability in AFC is observed, which is dictated by the reproductive efficiency during breeding. Herds can minimize the variability in AFC by obtaining high pregnancy rates, but poor reproduction increases variability in AFC, although nutrition and growth rates may be adequate (Ettema and Santos, 2004).

The relationship between AFC and milk yield has been investigated. The impact of AFC on milk yield shows a discrepancy in reports. It was shown that heifer calving at 26 mo of age produced similar amounts of 305-d milk in compare with the heifer calving at 24 mo of age (Heinrichs and Vazquez-Anon, 1993). Pirlo *et al*. (2000)

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found that reduction of AFC appeared to have a negative effect on first lactation milk yield and fat percentage; however, it had a positive effect on milk protein percentage. Vukasinovich *et al.* (2001) reported that the effect of AFC did not have a large influence on the length of productive life. It was shown that, the relative culling risk is curvilinear in Holstein cows, with slightly increased risk for cows that calve very early and especially very late. Greater culling risk for older ages at first calving may be related to reproductive problems (Vukasinovich *et al.*, 2001).

Impact of AFC on reproduction has been evaluated. While Ettema and Santos (2004) showed similar abortion percent with different ages at first calving, Thompson *et al.* (1983) found that problems of parturition increase significantly when AFC is less than 22 mo. Dystocia was one of the important problems when AFC decreased. Dystocia is detrimental to reproduction and health and BW of heifers at first calving impacts dystocia (Hoffman and Funk, 1992).

The objective of this investigation was to evaluate the effect of age at first calving on cumulative first 60 and 200 days milk production and also reproductive performance in first-parity Iranian Holstein dairy cows.

MATERIALS AND METHODS

Data regarding to all calving of cows were collected during 1996 until 2006 in seven large commercial Holstein farms. During the period the median number of cows in the study herds was 500. Farms were located in eastern north of Iran and were enrolled in the official milk-recording scheme. The farm selection was done among those affiliated with at least one of dairy cooperatives and was also based on the farmer's willingness to cooperate in the study. Each farmer had dairy management software in farm to collect the data and manage all dairy operations. Farmers have recorded information about all existing and culled cows. Each cow has been characterized by demographic data (birth date, sire, first calving date), production data (cumulative first 60 and 200 days milk productions) and reproduction data (calving class, sex and weight of calf at calving, next breeding information, days open). Collected data were checked for consistency of data. Finally, during the study period, a total of 9269 cows (females having calved at least one) were used.

Herds were characterized by dummy variables. The dependent variables analyzed were the cumulative first 60 and 200 days milk production, days open and calving class. The model for analyzing the cumulative milk yields included the AFC with 23 levels (from 17-40 mo, one per month), calf weight at calving, calving class with 4 levels (including eutocia, dystocia, stillbirth and abortion), days open, herd and calving year and season. The factors included in the model for analyzing days open were AFC with 23 levels (from 17-40 mo), calf weight at calving, calving class with 4 levels (including eutocia, dystocia, stillbirth and abortion), cumulative first 60 days milk production with 4 levels (less than 1644, 1644 to 2036, 2037-2405 and more than 2405 kg), herd and calving year and season. Data were analyzed using General Linear Models. The distribution analyze for the variables was done using the statistical software package JMP (SAS Institute Inc., NC, USA). The effect of the different levels of AFC on calving class was evaluated by nominal logistic analysis.

RESULTS

Age at calving averaged 27.23±3.37 month. The median was 26 mo and 25 and 75% quartiles were 25 and 28 mo, respectively. Its distribution showed almost a bell shape (Fig. 1). Age at first calving decreased from 1996-2006 ($p<0.01$, Fig. 2).

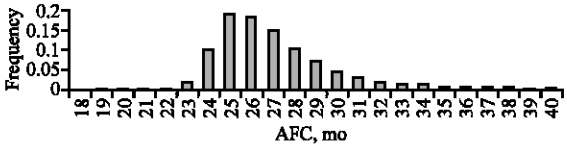

Fig. 1: Age at First Calving (AFC) in month in the Iranian Holstein cows (SE = 0.035)

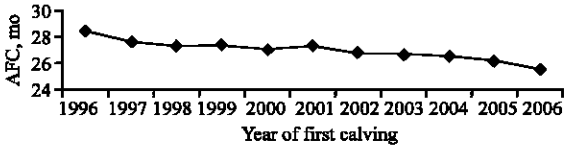

Fig. 2: Trend in Age at First Calving (AFC) over the years in the Iranian Holstein cows (SE = 0.14)

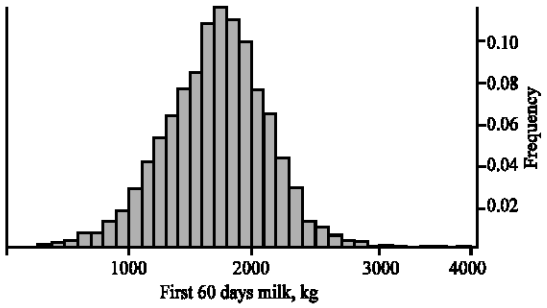

Fig. 3: Cumulative first 60 days milk production in the Iranian Holstein cows

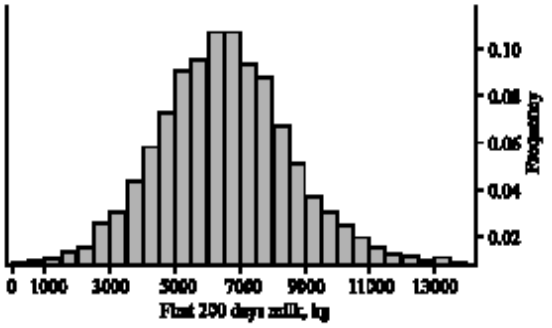

Fig. 4: Cumulative first 200 days milk production in the Iranian Holstein cows

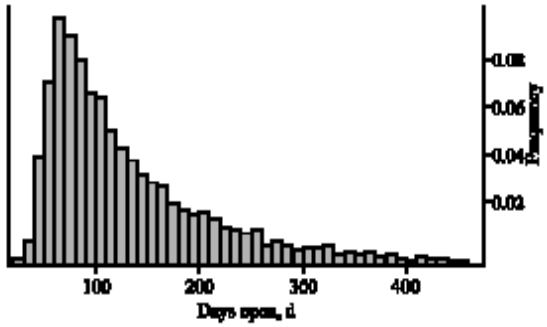

Fig. 5: Days open distribution in the first parity of Iranian Holstein cows

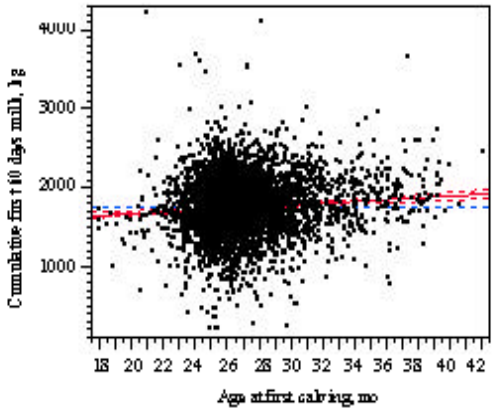

Fig. 6: Effect of age at first calving on cumulative first 60 days milk production in Iranian Holstein cows

Cumulative first 60 days milk production in the first calving averaged 1705.77 kg. The median was 1728 and 25 and 75% quartiles were 1443 and 1980 kg, respectively. Its distribution showed a normal distribution (Fig. 3). Cumulative first 200 days milk production in the first calving averaged 6536.21 kg. The median was 6480 and 25 and 75% quartiles were 5168 and 7789 kg, respectively. Its distribution also showed a normal distribution (Fig. 4).

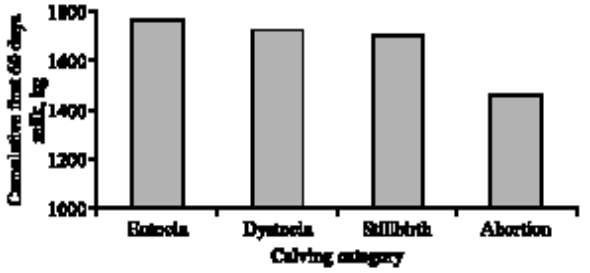

Fig. 7: Effect of calving class on cumulative first 60 days milk production in Iranian Holstein cows (SE = 150)

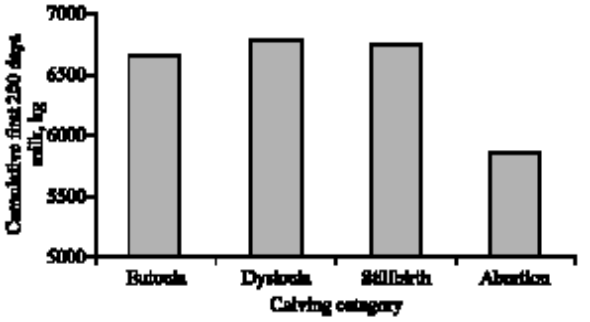

Fig. 8: Effect of calving class on cumulative first 200 days milk production in Iranian Holstein cows (SE = 500)

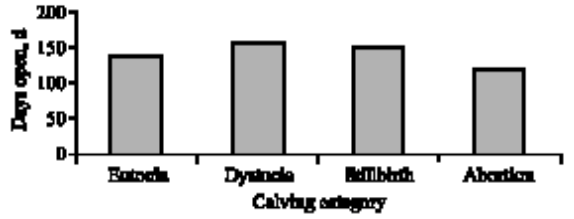

Fig. 9: Effect of different calving categories on days open in Iranian Holstein cows (SE = 39)

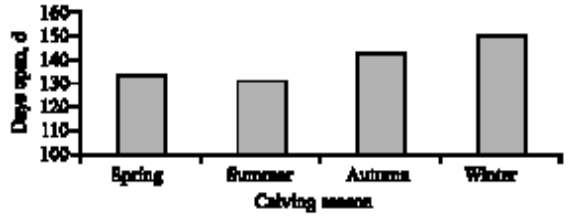

Fig. 10: Effect of calving season on days open in Iranian Holstein cows (SE = 39)

Days open (the interval between first calving and conception) averaged 136.88 d. The median was 109 d and 25 and 75% quartiles were 73 and 173 d, respectively. Its distribution showed a sharp increase and subsequent gradual decrease (Fig. 5).

Age at first calving had a significant impact on cumulative first 60 (Fig. 6) and 200 days milk production ($p<0.0001$) but days open was similar among different levels of AFC. The AFC has impacted the calving class and by increasing the AFC the probability of eutocia increased and the probability of calving difficulty decreased ($p<0.001$). Wald tests and Likelihood Ratio tests showed significant effect of AFC on calving class ($p<0.001$).

Cumulative first 60 and 200 days milk productions were also affected by calf weight at calving, calving class, herd and calving year and season ($p<0.001$). Days open had significant effect only on cumulative first 200 days milk production ($p<0.01$). The milk yields had a positive relation with calf weight at calving ($p<0.01$). Cows with eutocia and dystocia produced similar amount of cumulative first 60 days milk production (Fig. 7). Cows with abortion produced the lowest amount of cumulative first 60 (Fig. 7) and 200 (Fig. 8) days milk yields ($p<0.001$). While cows calved in spring had the lowest cumulative 60 days milk production ($p<0.001$), the summer cows had produced the lowest amount of cumulative 200 days milk production compare with the other seasons ($p<0.001$). Both milk yields were increased over the years ($p<0.001$).

Days open was impact by the calving class, herd and calving year and season ($p<0.001$). Figure 9 shows the effect of calving class on days open. Orthogonal comparisons showed significant difference between the abortion and other categories ($p = 0.05$). Days open was increased over the years ($p<0.001$). Calving season had a significant impact on days open ($p<0.001$, Fig. 10). Orthogonal comparisons showed that cows calved in summer and spring had lower days open compare with the other seasons ($p<0.001$). Days open was similar among cumulative first 60 days milk production categories.

DISCUSSION

Result of current study showed that age at calving averaged 27.23 month. Wolff *et al.* (2004) reported similar age in Brazilian cows (27.05±3.93 mo). In another study on Iranian cows (Nilforooshan and Edriss, 2004) AFC was reported 26.8 mo which is less than present study. The discrepancy might be related to different population. In the United States the average AFC of dairy cattle (mostly Holsteins) between 1985 and 1990 was 25.9 mo (Heinrichs *et al.*, 1994). The AFC reported in the present study is also higher than reported with Italian cows (26 mo; Pirlo, 1997) and less than the estimated mean of 28.6 mo in Spanish cows (Perez *et al.*, 1999). It was shown that mean age at first calving in 2002 was inversely related to herd size (USDA, 2002a) and within herd was 25.5 mo when herd size was <100 cows but only 24.6 mo when herd size was ≥500 cows. Ettema and Santos (2004) showed that 23-24.5 month at first calving had the highest economic return, lower days open and fewer number of inseminations. Two further studies by Pirlo *et al.* (2000) and Nilforooshan and Edriss (2004) also showed an optimum age at first calving of 23-24 months.

The result of present study showed that AFC was decreased over the time. Three USDA studies (USDA, 2002b) on dairy health and management practices were compiled based on data from US herds in 1991, 1996 and 2002 that represented 83-85% of US cows. Mean age at first calving within herd declined slightly from 25.9 mo in 1991 to 25.4 mo in 2002 and declined from 25.8 to 25.0 mo when weighted for cow numbers. Other studies have reported decreasing ages at first calving for dairy populations in The Netherlands and Spain (Hare *et al.*, 2006). Regression analysis of change in calving age over time showed significant decreases of 0.29 mo year^{-1} for Holstein cows during 1980-2004 in the US cows (Hare *et al.*, 2006). First parity calving age has also declined. The decreases might represent earlier maturity from better calf-raising practices or from intense selection for high milk yield during early parities (Hare *et al.*, 2006).

Our results showed a slight increase in cumulative 60 and 200 days milk production with increasing AFC. The results on the effect of AFC on first-lactation milk yield are inconsistent. Some reports showed positive effects of delayed AFC on milk yield (Moore *et al.*, 1991; Pirlo *et al.*, 2000). Yields of milk during first lactation were significantly lower for early-bred heifers and for every 1 mo of reduction in AFC, a decrease in 305-d milk, protein and fat of 96, 3.1 and 4.3 kg, respectively, was observed during first lactation (Lin *et al.*, 1988). However, lifetime production evaluated through the first 61-mo herdlife was improved for early-bred heifers. Nilforooshan and Edriss (2004) showed that by increasing AFC from 21-24 mo, milk yield increased, but with delayed onset of first lactations more than 24 mo of age, milk yield decreased. Bewley *et al.* (2001) also reported a negative effect of increasing AFC on milk yield. Hoffman *et al.* (1996) found that calving earlier than 22 mo of age had a negative influence on milk yield. The negative effect of early calving can be explained by high BW gain before puberty (Sejrsen and Purup, 1997). Age at first calving can be manipulated by altering growth rates. Van Amburgh *et al.* (1998) reduced AFC to 21.3 mo, with a prepubertal growth rate of 1.0 kg d^{-1} and observed a 5% reduction in yields of milk and 4% FCM compared with heifers fed to gain 0.6 kg d^{-1}, but indicated that reductions were associated with lower BW at calving for heifers calving at 21.3 mo. Results from a recent study

showed that heifers maturing at younger ages are better milk producers (Ruiz-Sanchez *et al*., 2007). However, even when heifers are managed and fed similarly to achieve similar growth rates, variability in AFC is observed, which is dictated by the reproductive efficiency during breeding (Ettema and Santos, 2004). Herds can minimize the variability in AFC by obtaining high pregnancy rates, but poor reproduction increases variability in AFC, although nutrition and growth rates may be adequate (Ettema and Santos, 2004). Durr *et al*. (1999) in a study of Quebec Holsteins stated that cows with a delayed first calving were less profitable due to higher rearing costs even though they produced more milk in their first lactation than cows calving around 24 months of age. The study found that all ages at first calving greater than 24 months of age had a higher risk of culling thus resulting in less lifetime potential to produce milk due to a fewer number of lactations.

The result of present study demonstrated that by increasing AFC the probability of eutocia increased and in turn the probability of calving difficulty decreased. Dystocia is detrimental to reproduction and health and BW of heifers at first calving impacts dystocia (Hoffman and Funk, 1992). Thompson *et al*. (1983) found a negative correlation between BW at first calving and dystocia. Younger, smaller heifers, as well as older and overconditioned heifers might experience more dystocia (Ettema and Santos, 2004). Simerl *et al*. (1991) showed that frequency of dystocia was greater in the young (<24 mo) and old (>27 mo) heifers. Theoretically, reduction of AFC can increase the number of calves per cow, but dystocia can reduce livability of calves as an inhibiting factor (Martinez *et al*., 1983; Thompson *et al*., 1983). Calving difficulty also might make the calves more susceptible to infections because of reduced absorption of immunoglobulins (Donovan *et al*., 1986). In contrast to our result, Pedron *et al*. (1989) and Simerl *et al*. (1992) did not find any relationships between AFC and reproduction. Thompson *et al*. (1983) also did not observe an increase in calving difficulty for heifers calving as early as 22 mo of age. Hoffman *et al*. (1996) found no differences in dystocia for heifers under different postpubertal feeding regimens with AFC of 20.6 or 23.6 mo. In the same study, delaying breeding to increase AFC by about 2 mo resulted in a higher incidence of dystocia and the higher BCS was suggested as the main reason.

The result of present study showed that the days open after first calving was similar among different levels of AFC. This is in contrast with a study by Ettema and Santos (2004) who reported that conception rate and days open were affected by age of calving. The study found higher first postpartum AI conception rates and lower days open in the medium (AFC = 701-750 d) compared to either the low (AFC ≤ 700 d) or high (AFC > 750 d) age groups. Evans *et al*. (2006) also showed a tendency towards lower subsequent CI in cows calving for the first time at ages of 25-26 months compared to both younger and older age groups at first calving.

Increased days open over the years in the present study is in consistent with other reports that showed days from calving to conception increased in cows from 1992-1998 (Rajala-Schultz and Frazer, 2003). Calving season had significant effect on days open in consistent with other report (Ettema and Santos, 2004).

CONCLUSION

The result of this study, demonstrated that the milk yields increased by increase in AFC but the AFC had no impact on the interval from calving to conception. Age at first calving had significant impact on calving class and the probability of calving difficulty decreased by increase in AFC. As delaying age at first calving is not cost effective, it is recommended that heifers calve between 23 and 25 mo of age. According to our results, it is demonstrated that mean AFC is higher than the optimum age at first calving and can be decreased by 4 months.

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